

Taxonomic Status of *Saussurea yakla* (Asteraceae) from the Himalayas

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Saussurea yakla was described by Clarke (1876), and Lipschitz (1979) placed this species in sect. Cyathidium of subgen. *Saussurea* based on the large size of its capitula and pinnatisect leaves. However, the chromosome number $2n = 34$ reported for the species is consistent with those of other members of *Himalaiella*, and the results of a phylogenetic analysis revealed that *S. yakla* is nested within *Himalaiella*. In addition *Saussurea yakla* is characterized by having 4–5-gonal, rugose pericarps with an irregularly toothed crown and uniform pappus arranged in a single row. These characters are also shared with the genus *Himalaiella*. The results of the molecular phylogenetic, cytological and morphological analyses all support a transfer of *Saussurea yakla* to the genus *Himalaiella*. A new combination, *Himalaiella yakla*, is made here.

Key words: *Himalaiella*, Himalaya, new combination, *Saussurea*.

Saussurea DC. (Asteraceae) comprises about 400 species classified into six subgenera distributed mainly in temperate and subarctic regions of Eurasia (Lipschitz 1979). Molecular phylogenetic analyses of *Saussurea* published by Häffner and Helling (1999), Raab-Straube (2003) Wang and Liu (2004), Kita et al. (2004), and Wang et al. (2005) suggest that the genus, as well as certain infrageneric taxa sensu Lipschitz (1979), are polyphyletic. In particular, studies by Raab-Straube (2003) and Kita et al. (2004) have made clear that the genus *Saussurea* is composed of two distinct clades, one containing the bulk of *Saussurea* s. l. as a sister to the monotypic genus *Hemistepta* (Kita et al. 2004), and the second consisting of subgen. *Saussurea* sect. *Elatae* and subgen. *Jurinocera* and *Frolovia*, as a sister group to the genus *Jurinea*. Detailed studies of *Saussurea* sensu Raab-Straube (2003) at the

subgeneric level, however, remain desirable to clarify species relationships and to provide a robust subgeneric classification based on molecular phylogenetic information. As such, it is suggested that a systematic investigation of the subgenera and their sections is now a priority for research in the genus.

Saussurea yakla was described by Clarke (1876). Lipschitz (1979) classified the species into sect. Cyathidium of subgen. *Saussurea* based on the size of the capitulum and pinnatisect leaves (Fig. 1). However, Fujikawa et al. (2004) reported that *S. yakla* has a chromosome number $2n = 34$, which is the same as the numbers of *Himalaiella* species analyzed, but differs from the numbers $2n = 30$ or 32 reported for all species of sect. Cyathidium examined so far (c.f. Fujikawa and Ohba 2003, Fujikawa et al. 2004).

A key component of this work is to determine taxonomic status of *Saussurea yakla* in

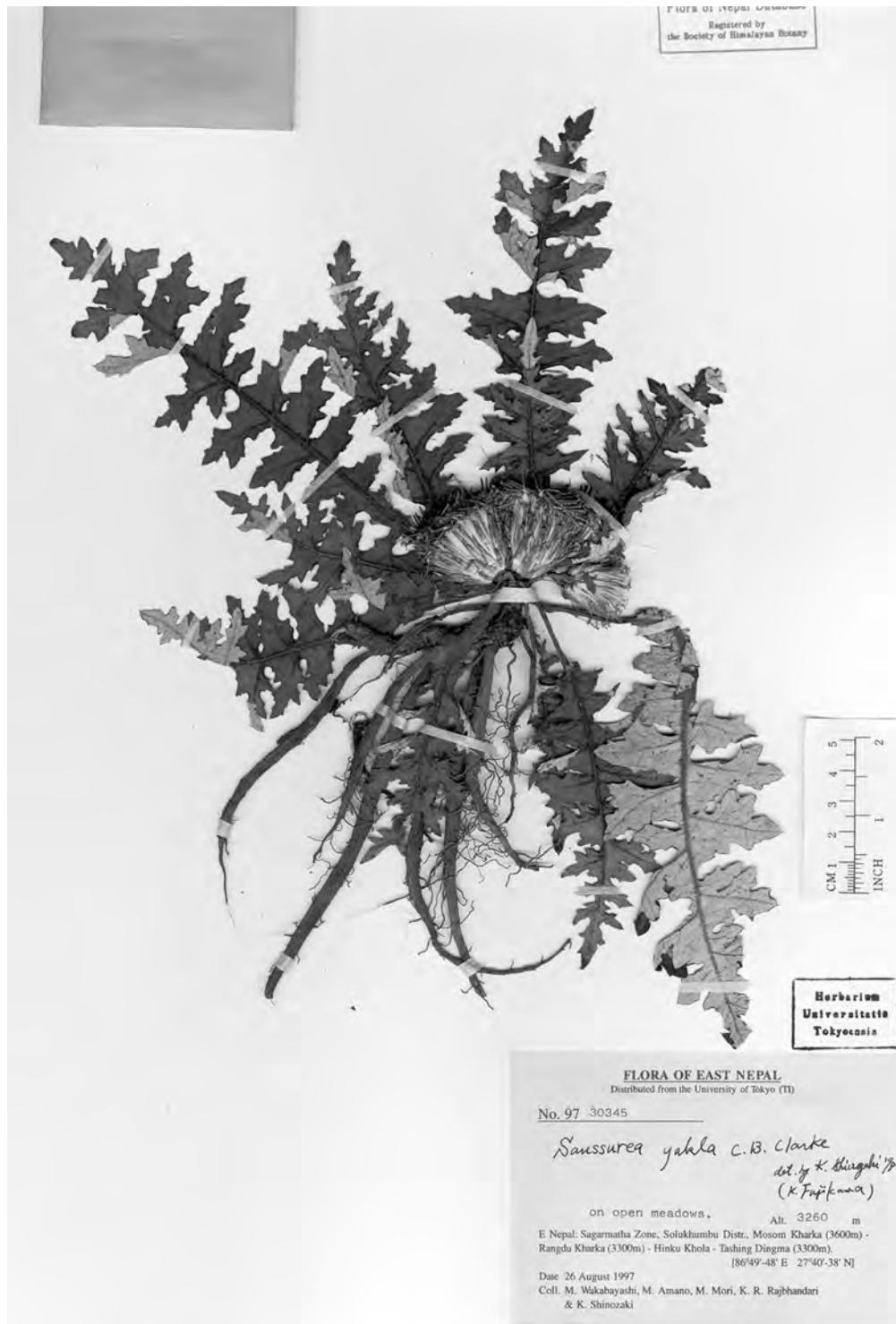


Fig. 1. *Saussurea yakla* C. B. Clarke. Nepal. Sagarmatha Zone, Solukhumbu Distr. Mosom Kharka-Tashing Dingma (Wakabayashi & al. 9730345, TI)

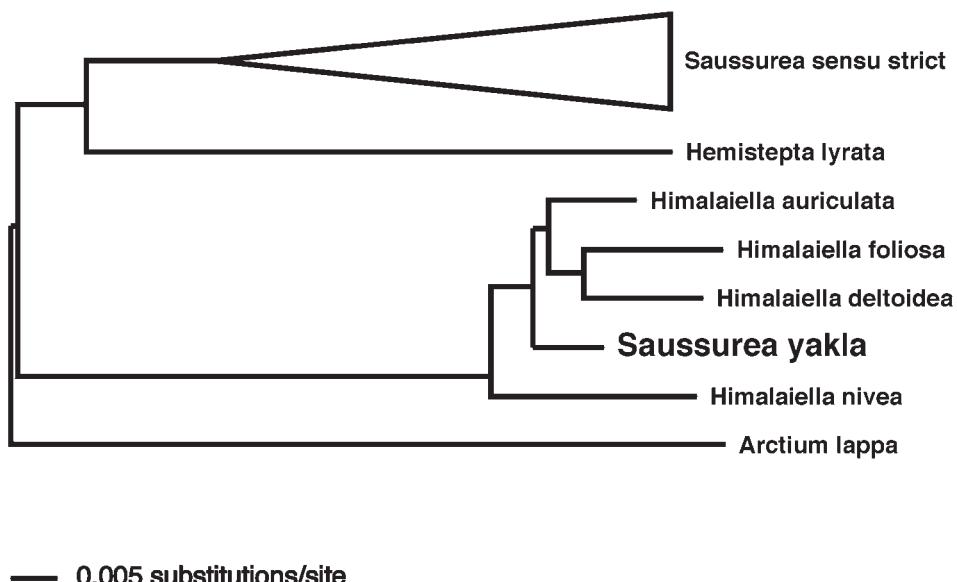


Fig. 2. A simplified Neighbor-Joining phylogenetic tree based on combined ITS + ETS sequence data for the genus *Saussurea*. Bootstrap probabilities of 1000 replicates are given above branches.

the context of a systematic study of the genus *Saussurea* (Fujikawa and Ohba 2003, Kita et al. 2004). The results of a phylogenetic analysis revealed that *S. yakla* is nested within *Himalaiella* (Kita et al. in preparation). We present here the results of morphological analysis of the achene and pappus of *S. yakla* in relation to the phylogenetic position and propose a new combination for this species.

Material and Method

Fresh material of *Saussurea yakla* was studied in the field, Hinku Valley in 1997 and Milke Danda in 1998, eastern Nepal (cf. Wakabayashi 1998, Fujikawa and Omori 2000). To clarify the morphological range of variation and distribution of the species, herbarium specimens from A, CAL, E, K and TI were also examined. Well developed synflorescences and capitula were collected from living plants in the field and fixed in FAA (5 parts formalin, 5 parts glacial acetic

acid and 90 parts 50 % ethanol). Florets at anthesis were used in the study, although the achenes at that stage were immature. Pappus bristles and achenes were also observed using a scanning electron microscope (SEM) (HITACHI S-2380N). Samples for SEM observation were dehydrated in an alcohol series and treated with isogamete-acetate. They were then dried in a critical point drier and coated with gold-palladium. Voucher specimens are deposited at the Herbarium of the University of Tokyo (TI).

Results and Discussion

An NJ phylogenetic simplified tree from the combined ITS and ETS sequence data of 72 taxa of the genus *Saussurea* previously analyzed by Kita et al. (in preparation) are shown in Fig. 2. The phylogenetic analysis revealed that *S. yakla* is nested within *Himalaiella* with a bootstrap probability of 100 % (Fig. 2).

Achene morphology was examined after

the phylogenetic analysis. *Saussurea yakla* has 4–5-gonal achenes, with squamulate to muricate pericarp bearing projections on the surface and an irregularly and sharply toothed crown-like structure and a single row of plumose pappus bristles (Fig. 3).

Morphological surveys of achene and pappus characters presented by Raab-Straube (2003) and Kita et al. (2004) distinguish sect. Elatae, and subgen. Jurinocera and Frolovia, which have uniserial pappus bristles and achenes with horns or dentate crown, from the remainder of the genus *Saussurea*. Raab-Straube (2003) adopted these results to redefine generic concepts, establish the new genus *Himalaiella*, and to resurrect the genera *Frolovia* (DC.) Lipsch. and *Lipschitziella* Kamelin.

The genus *Himalaiella* consisted of the previous members of sect. Elatae of subgen. *Saussurea*, but an affinity between *Saussurea yakla* and sect. Elatae has not been considered. *Saussurea yakla* shares achene characters with *Himalaiella*, i. e., a rugose, muricate or squamulate pericarp with an irregularly toothed crown, which resulted from an elongated pericarp beyond the apical plate, and a single row of pappus bristles (Table 1). On the other hand, the species of sect. Cyathidium usually have ovoid, obovoid to cylindrical achenes possessing smooth pericarps without apical crown, and dimorphic pappus bristles in two rows. A few exceptions are achenes and pappus bristles of *Saussurea sughoo* C. B. Clarke, *S. pachyneura* Franch. and *S. nepalensis* Spreng. They have uni- or biserrate, uniform or dimorphic pappus bristles, and rugulose or somewhat smooth with muricate, and having a crenuate, irregularly toothed or slightly toothed pericarpic crown (Table 1). However, no species of sect. Cyathidium except *Saussurea yakla* has combined features of 4–5-gonal, rugose pericarps with irregularly toothed crowns and uniform pappus bristles in a single row (Table 1). While the



Fig. 3. Scanning electron micrograph of achene and pappus bristles of *Saussurea yakla* (Voucher: Wakabayashi & al. 9730180, TI). Scale indicates 1 mm.

other species belonging to sect. Cyathidium have unbranched rhizome with fibers, *Saussurea yakla* has unbranched rhizome without fibers (Fig. 1).

Thus, all the results of molecular phylogenetic, cytological and morphological analyses support that *Saussurea yakla* should be included in the genus *Himalaiella*. A new combination, *Himalaiella yakla*, is consequently made.

Himalaiella yakla (C. B. Clarke) K. Fujikawa & H. Ohba, comb. nov.

Saussurea yakla C. B. Clarke in Compos. Ind.: 227 (1876) – Hook. f., Fl. Brit. Ind. 3: 368 (1881) – Kitam. in Acta Phytotax.

Table 1. Morphological features of pappus bristles and achenes of *Saussurea yakla* C. B. Clarke and resembling species of sect. Cyathidium subgen. *Saussurea*

	<i>Saussurea sughuo</i> C. B. Clarke*	<i>S. nepalensis</i> Spreng.** (DC.) Raab-Straube**	<i>S. pachyneura</i> Franch.*	<i>S. yakla</i> C. B. Clarke*	<i>Himalaiella auriculata</i> (DC.) Raab-Straube**
Pappus seriation	biseriate	uniseriate	biseriate	uniseriate	uniseriate
Pappus uniformity	uniform	uniform	dimorphic	uniform	uniform
Pappus shape	outer pappus bristles plumose, 3/4 shorter than inner ones, deciduous; inner ones plumose	plumose	outer pappus bristles scabrid to barbate, deciduous, inner ones plumose	plumose	plumose
Achene shape	obvoid - cylindrical	cylindrical	obvoid - cylindrical	4-5-gonal	4-5-gonal
Achene surface	smooth or ruglose with/without muricate on upper part	rugulose	ruglose with/without muricate on upper part	rugose with squamulate to muricate pericarp with/without projections	rugose with squamulate to muricate pericarp with sharp projections
Achene apex	crenate crown	irregularly toothed crown	crenate or slightly toothed crown	irregularly and sharply toothed crown	irregularly and sharply toothed crown

Data source: *present study; **Kita & al. 2004. Voucher specimens of *Saussurea yakla* are shown in the taxonomic treatment; those of *S. sughuo* are Long & al. 351 (E), 607 (E), 686 (E), L. Dhwoj 539 (E), Ribu and Rhomoo 282 (E); that of *S. pachyneura* is Ikeda & al. 101248 (T).

Geobot. 24: 9 (1969) – Lipsch., Genus *Saussurea*: 170 (1979) – Chater & Kitam. in H. Hara, Chater & Williams, Enum. Fl. Pl. Nepal 3: 41 (1982) – Grierson & Springate in Grierson & Long, Fl. Bhutan 2(3): 1445 (2001). **Lectotype** (here designated): SIKKIM: Yakla, 16000 ft., 18 Oct. 1869, C. B. Clarke 10191A. (K !; MBK-image !). Yakla, 15000 ft., 18 Oct. 1869, C. B. Clarke 9915B (CAL-syntype !; MBK-image !).

Jurinea cooperi J. Anthony in Not. Bot. Gard. Edinb. 18: 21 (1933). Type: Tibet, Chumbi, 26 Aug. 1913, R. E. Cooper 742 (E-holotype !; MBK-image !).

Monocarpic herbs. Rhizome unbranched with elongate and branched roots. Rosulate leaves subsessile or petiolate, petioles up to 6 cm long; lamina ovate to oblong, 5.0–40.3 × 3.0–8.2 cm, apex acute or obtuse with micron; margin pinnatisect; teeth triangular, ovate or oblong, 1–3.3 × 0.8–3.4 cm; green or dark green with conspicuous midribs, adaxial surface puberulent, with scattered glandular hairs and glands; abaxial surface white araneous, with glands, or glandular hairs and glands.

Flowers mid-August to November. Capitula sessile or subsessile, several or rarely solitary, up to 8, 2.5–4.0 cm in diameter. Involucre campanulate or bowl-shaped; involucral phyllaries imbricate, linear, lanceolate or ovate, in four to six rows, apex erect or reflexed, light brown, green or reddish, coriaceous to herbaceous; outermost phyllaries 0.5–1.0 cm long, innermost ones 2–3 cm long. Receptacles setose.

Corolla actinomorphic, 17.0–26.8 mm long (including lobes), lobes reddish purple or purple, 3.9–5.7 mm long, with glands dense to sparse on abaxial surface. Anthers sagittate, 0.5–0.9 mm long; tails 0.1–0.4 mm long, bluish white or blackish blue. Style purple. Achenes at anthesis, 2.5–5.4 mm long, 4–5-gonal with a squamulate to muricate pericarp bearing projections, apical pericarpic rim with irregularly and sharply

toothed crown structures. Pappus uniseriate, plumose, persistent, 1.6–2.5 mm long, base connate, cream-coloured or brownish.

Distribution and habitat: China (Xizang), Bhutan, India (Sikkim) and Nepal. Subalpine to alpine zone, 2400–5100 m; meadows and glassland.

Chromosome number: $2n = 34$.

Specimens examined: **CHINA.** Xizang Prov. (Tibet), Chumbi, 26 Aug. 1913, R. E. Cooper 742 (A); Yatung, 27°51'N, 88°35'E, H. E. Hobson 1897 (K); without precise locality and collector 12 Aug. 1898, s. n. (K). **BHUTAN.** Somana, 4371 m, 23 Aug. 1971, Ramesh Bedi 936 (K); Upper Mo Chu Distr., hillside above Laya 28°07'N, 89°44'E, 3930 m, 19 Sept. 1984, I. W. J. Sinclair & D. G. Long 5140 (E, K); Tongsa Distr., summit of Pele La, E side, 27°32'N, 90°11'E, 3300 m, 12 Oct. 1984, I. W. J. Sinclair & D. G. Long 5678 (E); Wangdi Phodrang Distr., Tampetso, 27°45'N, 90°31'E, 4000 m, 22 Sept. 1993, F. Miyamoto 9361643 (TI); 4400 m, 24 Sept. 1993, F. Miyamoto 9361675 (TI); 27°42'N, 90°31'E, 4160 m, 27 Sept. 1993, F. Miyamoto 9361749 (TI); Bhja, 27°37'N, 90°32'E, 3200 m, 18 Sept. 1993, F. Miyamoto 9361523 (TI); Bhumtan Chu Distr., Domchen, 27°46'N, 90°34'E, 4150 m, 25 Sept. 1998, Wangdi Kinzang B2 (E); without precise locality, Oct. 1935, Bemark 879 (CAL). **INDIA.** Sikkim, 11–13000 ft., J. D. Hooker s. n. (K); Lecha, Sept.–Oct. 1909, 2438 m (8000 ft.), Ribu & Rhomoo 3019 (CAL); Kang Pupchu Thang, 4877 m (16000 ft.), 15 Nov. 1911, Ribu & Rhomoo 5684 (K); Tarkarpo, 3353 m (11000 ft.), 12 Sept. 1912, Rhomoo Lepcha 100 (E, K); Chamnago, 3962 m (13000 ft.), 24 Sept. 1913, R. E. Cooper 948 (E); S. of Sherabthang, 4572 m (15000 ft.), 25 Aug. 1913, R. E. Cooper 617 (E); Tosa, 4420 m (14500 ft.), Sept.–Oct. 1914, Ribu & Rhomoo 7046 (E); Changu, 3658 m (12000 ft.), 20 Sept. 1916, C. H. Cave s. n. (E); 24 Oct. 1916, C. H. Cave s. n. (E); Chatlong, 3658 m (12000 ft.), 24 Sept. 1920, C. H. Cave s. n. (E); without precise locality, C. H. Cave 722 (E). **NEPAL.** Koshi Zone, Sankuwasa Distr., Jaljale Himal, Singoa Kharka–Pahakhola, 27°35'N, 87°25'E, 4140–2400 m, 11 Aug. 1991, H. Ohba & al. 9110455 (TI); Chyakesha–Kibuk–Jaggu Danda–Sano Birke–Lachembu–Dogor Phuk, 27°39'N, 87°07'E, 4150 m, 27. Aug. 1997, S. Noshiro & al. 9760443 (TI); Sagarmatha Zone, Solukhumbu Distr., Mosom Kharka–Rangdu Kharka–Hinku Khola–Tashing Dingma, 27°40'N, 86°49'E, 3260 m, 26. Aug. 1997, M. Wakabayashi & al. 9730345 (TI); Gosaikund–Surjakund–Gopte, 4200–3500 m, 25 Aug. 1972, H.

Kanai & al. s. n. (E); Maney Dara 3962–4267 m (13–14000 ft.), L. Dhwoj 613 (E); without precise locality, 1977, Kanai & al. 770821 (TI); without precise locality 1927, C. Wigram s. n. (E).

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藤川和美^a, 喜多陽子^b, 大場秀章^c: ヒマラヤ産トウヒレン属 *Saussurea yakla* (キク科) の分類学的位置

Clarke によって 1876 年に記載されたトウヒレン属 *Saussurea yakla* は、頭花が大きく、葉が羽状分裂する特徴により、トウヒレン亜属 *Cyathidium* 節に分類されていた。本種の染色体数が $2n = 34$ で *Cyathidium* 節内では特異的であり、*Himalaiella* 属の分類群と同じ数であることが判明した。また分子系統解析でも *Himalaiella* 属と単系統群を形成することが推定された。そこで、*Saussurea yakla* の形態的特徴を再検討した。その結果 *S.*

yakla は *Himalaiella* 属の共有派生形質である、一列性の羽毛状の冠毛のみをもつこと、瘦果の表面に鱗状の突起をもつこと、瘦果の先端が突起状に切れ込む王冠状になる特徴を有することが明らかとなった。従って、本種に新組み合わせ *Himalaiella yakla* (C. B. Clarke) K. Fujikawa & H. Ohba を与えた。

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